DO YOU NOTICE WHAT I NOTICE? PRODUCTIVE MEDIUMS FOR TEACHER NOTICING

Megan H. Wickstrom
Montana State University
megan.wickstrom@montana.edu

This article is a report on the findings of three case studies that focused on elementary teachers' in-the-moment noticing across a month of instruction. Extending Jacobs and her colleagues' framework (Jacobs, Lamb, and Philipp, 2010), this articles categorizes the mediums (i.e., written accounts, verbal interactions, physical strategies) by which the teachers attended to their students' mathematical reasoning. Even though the teachers taught similar lessons, they attended to students' actions through different mediums. These mediums reflected and often aligned with individual teaching practices and routines. More interestingly, the teachers' preferred medium was also the most productive for them in terms of discussing students' understanding and informing instructional decisions.

Keywords: Teacher Knowledge; Teacher Beliefs; Mathematical Knowledge for Teaching

Background

In our everyday lives, we each attend to and notice different things. When walking down a city street, some of us might be drawn to the items displayed in a storefront window, others to the aroma of a local restaurant, and some may be drawn to something that they have seen before or perhaps something that has changed. We each make sense of our world in different ways and may not notice the same details. As Schoenfeld (2011) states, "noticing is consequential-what you see and don't see shapes what you do and don't do" (p.228). What we notice and make sense of shapes our daily decision-making processes.

In a similar sense, what teachers notice and make sense of in the classroom is often different depending on the teacher. Erickson (2011) found that teacher noticing is selective (attending to some events, but not to others), multi-dimensional, and influenced by prior experience. He also noted that teachers most often noticed events in the classroom that required immediate attention or action on the part of the teacher. Even though teachers notice many things during instruction, how to respond to what they notice is sometimes difficult. Multiple researchers (Berliner, 2001; Jacobs, Lamb, & Philipp, 2010; Mason, 1998) have documented that teachers often have difficulty devising instructional responses based on what they notice.

Even though noticing and responding to students' thinking is a difficult task, researchers have shown, with professional development, it is a learnable skill (Jacobs et al., 2011; Santagata, Zannoni, & Stigler, 2007). Using mediums such as classroom artifacts (Goldsmith and Seago, 2011), student video cases (Jacobs et al., 2010;), and videos of teachers' in-the-moment noticing, researchers noted growth in teachers' abilities to attend to students' mathematical thinking and form instructional responses.

With regard to in-the-moment noticing, researchers have devised ways for teachers to capture moments as they occur using a Déjà Vu camera and then later reflect and respond to these moments. This camera attaches to the teacher's body and she can press a button to capture 30 seconds of video at any time. Sherin, Russ, and Colestock (2011) discussed that teachers often use these cameras in multiple and unexpected ways (i.e., using it as a still life camera). Star, Lynch, and Perova (2011) took this idea a step further and categorized what pre-service teachers noticed during practice (i.e., classroom environment, classroom management, tasks, mathematical content, and communication).

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When using the Déjà Vu camera and analyzing their own teaching, teachers have the freedom to choose what is significant to them. By using this camera, researchers can gain insight into how teachers attend to and make sense of their students' mathematical reasoning. There is little to no research examining the types of events teachers choose in their daily practices and why these events are significant. It important to investigate the ways in which teachers naturally attend to students' actions and reasoning.

Within this paper, I categorize the mediums used by three teachers to attend to their students' mathematical thinking across a month-long unit of instruction. In art, a medium is the substance the artist uses to create his or her artwork. Within this paper, medium refers to the way in which what was noticed was conveyed to the teacher (i.e., drawing a picture, counting using fingers). The paper describes a framework for categorizing mediums as well as the significance of specific mediums for individual teachers. Within the paper, I address the following research questions:

- By what mediums do teachers attend to students' mathematical thinking in the classroom?
- In what ways, if any, do these mediums aide in teachers' instructional decision-making?

Theoretical Framework

This study is grounded in the theory of teacher research. Cochran-Smith and Lytle (1993) defined teacher research as "systematic, intentional inquiry by teachers about their school and classroom work" (p.24). Teacher research usually stems from issues and questions that arise within the practice of teaching. It is grounded in the epistemological belief that teachers should have a voice and a presence in the research community and acknowledges that the teachers' perspectives are critical when implementing and evaluating research.

This paper embraces this theory by examining teacher noticing from the teachers' perspectives. When we, as researchers, investigate teacher noticing, we often have an end goal in mind or something we hope teachers notice and respond to. By allowing teachers to choose important events, we gain insight into their natural practices and how they use these practices to guide decision-making.

Methods

Participants

Three teachers participated in the study: Mrs. Grey, Mrs. Purl, and Mrs. Brownstein. Mrs. Grey and Mrs. Purl were both fourth-grade teachers while Mrs. Brownstein taught fifth grade. The teachers had 10-18 years of teaching experience and were second-year participants in a two-year professional development (PD) focused on measurement topics. Throughout the PD, each of the teachers had experiences watching and writing about videos of their teaching in terms of students' thinking and instructional implications. These teachers were chosen as case studies from the PD because they taught similar grade levels at the same school, Terrace Elementary.

Terrace Elementary

The study took place at Terrace Elementary, located in an urban city in the Midwestern United States. At the time of the study, 554 students attended Terrace and of these students 54% were boys, 46% were girls. They identified according to the following ethnicities: 54.7% Black, 23.3% White, 10.3% Multiracial, 9.6% Hispanic, 1.6% Asian, 0.4% Native American, and 0.2% Native Hawaiian. The average class size of the school was 18 students and the student to teacher ratio was 12 to 1. At the time of this study, 80% of the students came from low-income households and were eligible for free or reduced-price school meals.

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Data Collection

During a month-long unit on measurement topics, each teacher was asked to wear a Déjà Vu camera to record events that she noted as important. This camera was a small device pinned to the teacher's shirt that connected to a collection box clipped to the teacher's pants. When the teacher pressed a button on the collection box, the camera collected and saved a 30-second video clip of the events prior to her pressing the button. Each teacher was asked to press the button on the camera when she felt that she noticed something important about students' thinking or when she made an important decision based on student thinking. All of the lessons were videotaped with a secondary camera, as well.

At the end of each day, I watched the videos and marked time stamps on the main video for each of the events that the teachers found important. These clips were then used as the main focus of a one-on-one interview. On a daily basis, each teacher and I would sit down for an interview in which we discussed the clips that she noted. For each clip, the teacher was asked to describe what the student(s) was doing, why she chose the clip, what she thought the student was thinking or understood, and in what ways this clip might inform her instruction going forward.

Following each teacher-researcher interview, I transcribed each conversation verbatim. This resulted in over 300 pages of written transcripts (100 pages per teacher).

Data Analysis

To examine what and how the teachers noticed, I began with the teacher noticing framework (Jacobs, Lamb, & Philipp, 2010) as my primarily analytical tool. However, the construct of teacher noticing has been primarily used in clinical interview settings and I experienced limitations in analyzing the data I had collected for this study. Using qualitative methods (Miles, Huberman, & Saldana, 2014), I instead envisioned the three tenets of teacher noticing as broader analytical categories to be explored. I incorporated provisional coding (Miles, Huberman, & Saldana, 2014) to expand and elaborate codes to better fit the aims of this study.

I decided to call each episode that the teacher noticed an event. The event was composed of four components: what the teacher noticed, interpreted understanding, implications for teaching, and significance to the teacher. It is important to note that an event could be composed of multiple student actions because a child could be doing two things simultaneously (e.g., drawing and counting area units).

I began the analysis by first reading the transcripts and taking descriptive, qualitative notes about each of the events. I recorded where an event began and ended and notes related to each of the constructs. I repeated this process for each of the teachers. Following the note-taking phase, I used an event-listing matrix (Miles, Huberman, & Saldana, 2014) to record the events the teacher noted in a chronological manner. I devised a matrix for each teacher in which the columns were the analytical categories of the event (what the teacher noticed, interpreted understanding, implications for teaching, and significance to the teacher) and the rows represented a description of each event in terms of those categories.

Because of the brevity of this piece and the focus on mediums of teacher noticing, I will only describe how what the teacher noticed was coded. For each event, I began by coding what the teacher noticed within the event and what task the action centered around. After each event was coded, I scanned the events again to see if codes were similar in nature or could be collapsed. I repeated this process for each lesson and each teacher. For this piece of analysis, the codes usually centered on specific tasks or routines within the classroom. As new codes emerged in the analysis, I reanalyzed each event for each teacher looking to see if the code had been missed.

For each teacher, I created codes that described what the event pertained to. In the results section, each of these codes are described in detail in the mediums framework (See Fig 1).

Results

What the Teacher Noticed		Description
Written Accounts	**Drawing Strategy**	The event involved a student's drawing a picture to represent or help find their answer.
	Written Answer	A solution or student's work recorded during instruction.
	Journal Account	Written reflections, definitions, and homework recorded by students in their journal.
Verbal Interactions	**Statement**	The student makes a claim or states a response in class.
	Question	The student poses a question to the teacher.
	Student to Student Interactions	Interactions, discussions, conversations made by students to each other within groups or pairs.
	Language Comprehension/Usage	The way in which students use and interpret language. Example: The teacher notices the student is confusing the words area and perimeter.
Physical Strategies	**Length/Area/Volume Counting Strategy**	The way in which the child counts length, area, or volume. Example: For area, students may count individual units, skip count by rows, or use the algorithm.
	Length/Area/Volume Measurement Strategy	The student uses tools to find length, area, or volume. Example: laying tiles down and counting them to find the area of a rectangle.
	Building Strategy	Students using tools to construct something. Example: Building a rectangle with a certain area or a prism with a certain volume.
Visualization Strategies	**Visualization Strategy**	A statement, the student makes, involving how they see volume or area. Example: Students states that the volume of a prism is like an elevator visiting multiple floors.
Non-Mathematical Behaviors	**Behavior**	Mainly non-mathematical events such as students rushing to complete a problem or not attempting a task.

Figure 1: Mediums by which the teachers attended to students' actions

When using the Déjà vu camera to indicate important events, the teachers noticed different types of student actions related to length, area, and volume measurement. These actions centered around five themes: written accounts, verbal interactions, physical strategies, visualization strategies, and non-mathematical behaviors (as shown in Fig 1). The types of actions the teachers attended to varied by teacher (as shown in Figure 2). Mrs. Purl primarily attended to verbal interactions, Mrs. Grey to written accounts, and Mrs. Brownstein to physical strategies. The teachers' classroom norms and practices often aligned with the ways in which they attended to students.

Written Accounts. Written accounts included when teachers noticed students' written strategies, drawings, or journal accounts. Of the three teachers, Mrs. Grey most often noted students' written accounts. Mrs. Grey reflected that she found it difficult, at times, to manage her classroom and implemented the concept of a math journal. On a daily basis, Mrs. Grey asked students to write down thoughts, explanations, and definitions in a personal journal. The math journal allowed her to maintain control while also allowing students to write and reflect on their mathematical understanding. Mrs. Grey viewed the journal as a window into her students' mathematical reasoning.

When asked to use the Déjà Vu camera, Mrs. Grey often used it as a still life camera to take photos of students' work or drawings. In the transcript below, Mrs. Grey had asked students to write their own definition of area, prior to instruction. She noticed one student's definition changed over time and speculated what the student might be thinking.

Researcher: What stood out to you at this moment?
Mrs. Grey: I think it was in her definition that she wrote down. When I looked at it, her definition was "area is the inside of a triangle, rectangle, or square". So that was when I asked her about the inside of a circle. Then, when we talked about changing our definition today, as a class, and I noticed she wrote "area is the inside of every shape and every shape has area".
Researcher: So what do you think she was thinking, initially?
Mrs. Grey: Um, it looks like maybe, from her drawing, that the units we use to fill in a shape don't fit the right way into a circle or oval because she is drawing square-ish shapes.

For Mrs. Grey, students' drawings and written explanations were powerful in helping her to see the ways in which students were reasoning about mathematics.

Verbal Interactions. Verbal interactions included statements, questions, language comprehension, and student-to-student interactions. Of the three teachers, Mrs. Purl primarily attended to students' verbal interactions. Mrs. Purl's classroom was designed as ELL (English Language Learners). During interviews, she described the need to help students explain their thinking aloud as well as explore the meaning of different words. She listened carefully to students' discussions, purposefully arranged students in groups or pairs, and encouraged them to share ideas aloud. During instruction, Mrs. Purl circulated the classroom and listened to different groups as they worked. For example, when measuring the area of a rectangle using tiles, Mrs. Purl noticed that two girls were using rulers as place markers to help structure rows and columns. The place markers took up space and Mrs. Purl noted the conversation that unfolded between the girls. She stated,

I loved the interaction between Stephanie and Marlaysia. Stephanie thought using the rulers to mark rows and columns was a great idea, but she was missing the space under the ruler where she used them. Marlaysia realized and explained to Stephanie that the ruler took up space so their measurement was off.

Mrs. Purl often noted the questions students posed as well as the wording they used. She thought that this could tell her more about the ways in which students were thinking mathematically and what remained unclear to the class.

Physical Strategies. All of the teachers used square tiles, cubes, and measurement tools to help students study length, area, and volume. They attended to students' physical strategies as they measured, counted, and built areas and volumes. Mrs. Brownstein, a math and science teacher, frequently used physical materials as a starting point in the lesson. She noted how students counted volume units and the strategies they used. For example, when asked to find the volume of a rectangular prism that was 10 units high, 10 units wide, and 5 units long, Mrs. Brownstein noticed Promise's counting strategy.

She was able to count 50 in a layer by then she ended up focusing on rods (vertical sections) of 10 and skip counting by 10. I think she is moving from seeing rods to seeing layers, but she isn't using the layers to find the total volume. Last class period she was able to count 50 (cubic units) in a layer but when I asked her to find the total volume she focused in on the rods of 10.

Beyond counting strategies, physical strategies also involved the ways in which students used a ruler, how they used tools like tiles to measure area, and how they built different figures with specified areas or volumes.

Visualization Strategies. Teachers also noted visualization strategies during instruction. These strategies were statements that included how students imagined area or volume or metaphors for area and volume. During a hands-on volume task, Mrs. Brownstein noticed students discussing the idea of volume as an elevator, a hamburger, and a waterfall. She stated:

> When I heard him say elevator, he was describing this kind of motion (moving her hand up and down). From what he said, I think that he is imagining a cart or an elevator going up and going down the prism.

It is important to note that visualization strategies were always coded with another strategy. Students had to speak or write down how they imagined the concept for the teacher to notice it.

Non-Mathematical Strategy. Lastly, teachers sometimes noticed students' non-mathematical behaviors in relation to the task. This included teachers describing that students had worked too quickly through the task, or they did not put enough thought into it. Since teachers were asked to focus on what they noticed mathematically, these events did not arise often.

Mediums by which the teacher attended to students' strategies.		Teachers		
		Mrs. Purl 37 Events 48 Student Actions	**Mrs. Grey** 24 Events 31 Student Actions	**Mrs. Brownstein** 27 Events 29 Student Actions
Written Accounts	**Drawing**	4	6	0
	Written Strategy (in class)	0	1	2
	Journal Account	0	6	0
	Total	**4 (8%)**	**13 (42%)**	**2 (7%)**
Verbal Interactions	**Statement**	8	6	1
	Question	1	0	0
	Student to Student Interaction	3	1	2
	Language Usage/Comprehension	2	1	5
	Total	**14 (29%)**	**8 (26%)**	**8 (28%)**
Physical Strategies	**Length Measurement Strategy**	2	0	N/A
	Length Counting Strategy	0	0	N/A
	Area Measurement Strategy	10	4	0
	Area Counting Strategy	9	5	0
	Building Strategy	1	0	0
	Volume Measurement Strategy	N/A	N/A	4
	Volume Counting Strategy	N/A	N/A	8
	Total	**22 (46%)**	**9 (29%)**	**12 (41%)**
Visualization Strategies	**Area Visualization**	6	0	0
	Volume Visualization	N/A	0	6
	Total	**6 (13%)**	**0 (0%)**	**6 (21%)**
Behaviors	**Non-Mathematical Behavior**	2	1	1
	Total	**2(4%)**	**1 (3%)**	**1 (3%)**

1 Implication Arose | 2 Implications Arose | 3 Implications Arose

Figure 2: Mediums that led to instructional implications

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Significance of the Mediums. Each of the teachers attended to students' actions through different mediums, as shown in Figure 2, even though they enacted similar lessons. Mrs. Purl primarily attended to students' physical strategies (46%) and verbal interactions (29%), while Mrs. Grey attended to students' written accounts (42%) and physical strategies (26%). Mrs. Brownstein noticed students primarily through physical strategies (41%) and verbal interactions (28%). It is important to consider these mediums because they can act as pathways into how the teachers see and understand their students.

As prior researchers have noted (Jacobs et al., 2010), it is difficult for teachers to enact the cycle of noticing students' actions, reasoning about the students' thinking, and describing implications for instruction. Teachers often see students doing something but are unsure of what the student is thinking and how the students' thinking can be addressed in instruction. For example, the teachers within this study were only able to complete this cycle for 22% to 25% of events noticed (Mrs. Grey, 25% of events, Mrs. Purl, 25% of events, Mrs. Brownstein, 22% of events).

In figure 2, the cells that are shaded show student events in which the teacher was able to describe students' thinking as well as implications for instruction. Cells that are darker indicate a greater number of events led to instructional implications. The darkest cell indicates that three of the events led to instructional implications while the lighter cells indicate two events and one event. For example, in the table, we can see that Mrs. Grey noticed six events that involved students drawing. Of these six events, three of them resulted in an implication for instruction.

As shown in Fig 2, the student actions that teachers attended to most frequently were the most productive for describing students' thinking and instructional implications. For example, Mrs. Purl, who primarily attended to students verbal interactions, had five incidences where she was able to describe students' understanding and instructional implications related to verbal interactions. This was the highest of any of the categories. The same is true for Mrs. Grey in terms of written accounts and Mrs. Brownstein in terms of physical strategies.

Discussion and Concluding Remarks

In considering the cases of Mrs. Brownstein, Mrs. Purl, and Mrs. Grey several themes emerge. The data highlights that teachers notice in different ways when teaching. The mediums by which teachers notice are often dependent on the tasks they pose, classroom norms and practices, and beliefs. Strategies that teachers use on a daily basis (i.e., math journals, encouraging discussions) can be productive mediums and pathways for teachers to glimpse students' mathematical thinking.

Secondly, the types of actions more frequently noticed were also most productive in reasoning about students' thinking and instructional decisions. Each of the teachers had 10 or more years of teaching experience and noticed in ways that aligned with their teaching. This result seems logical because the teachers had many years to think and reflect on their teaching and its ramifications. For example, Mrs. Grey used mathematics journals for several years and had practice reading and reviewing students' journals. It made sense that she could see things about her students through these journals that perhaps she had witnessed before.

This article highlights that teachers learn about their students through multiple and varied mediums. As researchers, it is important to consider this phenomenon when working with teachers and choosing professional development tasks. Examining teachers' current practices can aide in determining how best to help teachers understand students' thinking and reasoning. It is also important to expose teachers to multiple and varied mediums by encouraging multiple forms of expression in the classroom.

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